AN2722
Application note

Demonstration board user guidelines for the TS4601B high-performance stereo headphone driver

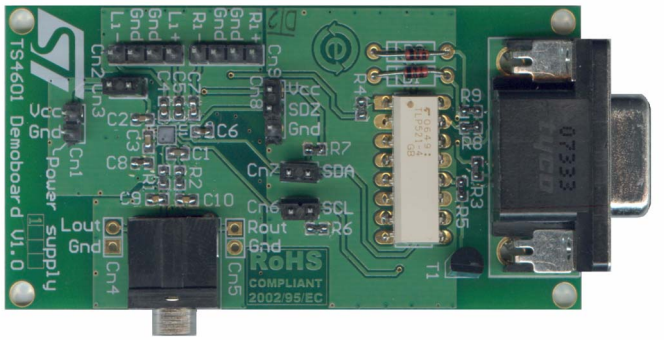
Introduction

This application note concerns the TS4601B's demonstration board, designed to evaluate the TS4601B, a high-performance stereo headphone driver with capacitor-less outputs and I^2C interface from STMicroelectronics.

This document provides:

- a brief description of the TS4601B device.
- a description of the demonstration board and all of its components.
- a description of the TS4601B control software provided.
- the layout of the demonstration board.

Figure 1. TS4601B demonstration board



About the TS4601B

The TS4601B is a stereo headphone driver dedicated to high audio performance and space-constrained applications. It is based on a low-power dissipation amplifier core technology. Special care was taken in the design of the amplification chain to achieve peerless PSRR (107 dB typ. at 217 Hz) and 101 dB of SNR.

The TS4601B can drive at minimum 0.9 V_{rms} output voltage into 16 Ω and 1.6 V_{rms} into 10 kΩ, regardless of the power supply voltage, in the range of 2.9 to 5.5 V.

An I²C interface is used to control the volume through 64 steps ranging from -60 dB to +4 dB and to configure the device in multiple modes. The traditionally-used output-coupling capacitors can be removed and a dedicated common-mode sense pin suppresses parasitic noise from the jack.

The TS4601B is designed to be used with an output serial resistor. It ensures unconditional stability over a wide range of capacitive loads. It is packaged in a tiny 16-bump flip chip package with a pitch of 500 µm and a 300-µm diameter ball size.

The TS4601B has the following key features.

- Power supply range: 2.9 to 5.5 V
- 107 dB of PSRR at 217 Hz
- Fully-differential inputs
- I²C interface for volume control
- Digital volume control range from -60 dB to +4 dB
- 101 dB of SNR A-weighted
- Independent right and left channel shutdown control
- Low quiescent current: 4.8 mA typ. at 3.0 V
- Low standby current: 2 µA max
- Output coupling capacitors removed
- Flip-chip package: 2.1 mm x 2.1 mm, 500 µm pitch, 16 bumps

Refer to the datasheet for complete information on the TS4601B.

1 Description of the demonstration board

The TS4601B demonstration board is designed to help you evaluate the TS4601B audio differential input stereo headphone amplifier. The TS4601B device, in a flip chip package, is mounted on a four-layer PCB. An on-board RS-232 to I^2C interface makes this board easy to control from a personal computer by using its serial port.

The provided software controls all of the TS4601B's features (gain, mode, mute, standby and register status).

You can use the connectors on the demonstration board to directly control some of the features.

- The master standby of the TS4601B can be set directly by Cn8 or, if the jumper is removed, by an external digital control (see *Table 1*).
- By removing the jumpers on Cn6 and Cn7, you can disconnect the on-board I^2C interface so that you can control the TS4601B by an external I^2C bus interface.
- The -3 dB cut-off input high-pass filter is set at about 6 Hz (C4 to C7). If you want to change this frequency, you have to replace C4 to C7 at the same time. More information about these component calculations is available in the TS4601B datasheet.
- The actual current consumption of the TS4601B can be measured directly by removing the jumper on Cn3 and inserting a DC amperemeter in series. The overall current consumption of the demonstration board is higher than the consumption of the TS4601B because the Cn1 power supply connector supplies the RS-232 to I^2C adapter in addition to the TS4601B.

Table 1. Demonstration board connectors

Connector	Description
Cn1	Power connector (V_{CC} and GND). Power supply voltage from 2.9 V to 5.5 V.
Cn2, Cn9	Fully-differential positive and negative input signal connectors (active input signal and GND). By shorting one active input to GND, you can use the demonstration board in single-ended input mode (refer to the TS4601B datasheet for more information).
Cn3	Connector that allows direct measurement of TS4601B's current consumption. Remove the jumper and insert a DC amperemeter.
Cn4	Left output connector (GND and active signal).
Cn5	Right output connector (GND and active signal).
Cn6, Cn7	SCL and SDA connectors: – pins shorted, TS4601B is controlled by the on-board RS 232 to I^2C interface. – pins unshorted, TS4601B can be controlled by an external I^2C bus.
Cn8	Standby control connector: – when pins 1 and 2 are shorted, the TS4601B is in operation mode. – when pins 2 and 3 are shorted, the TS4601B is in master standby mode. The connector pins are connected as follows: – pin 1 to V_{CC} – pin 2 to SDZ of the TS4601B – pin 3 to GND

Table 1. Demonstration board connectors (continued)

Connector	Description
J1	3.5 mm stereo headphone plug.
J2	DB9 female connector enabling connection of the demonstration board to the RS-232 serial port.

Caution: When you apply the power supply through Cn1, **do not** invert the polarity as this will damage the U1 amplifier.

Figure 2. Schematic diagram

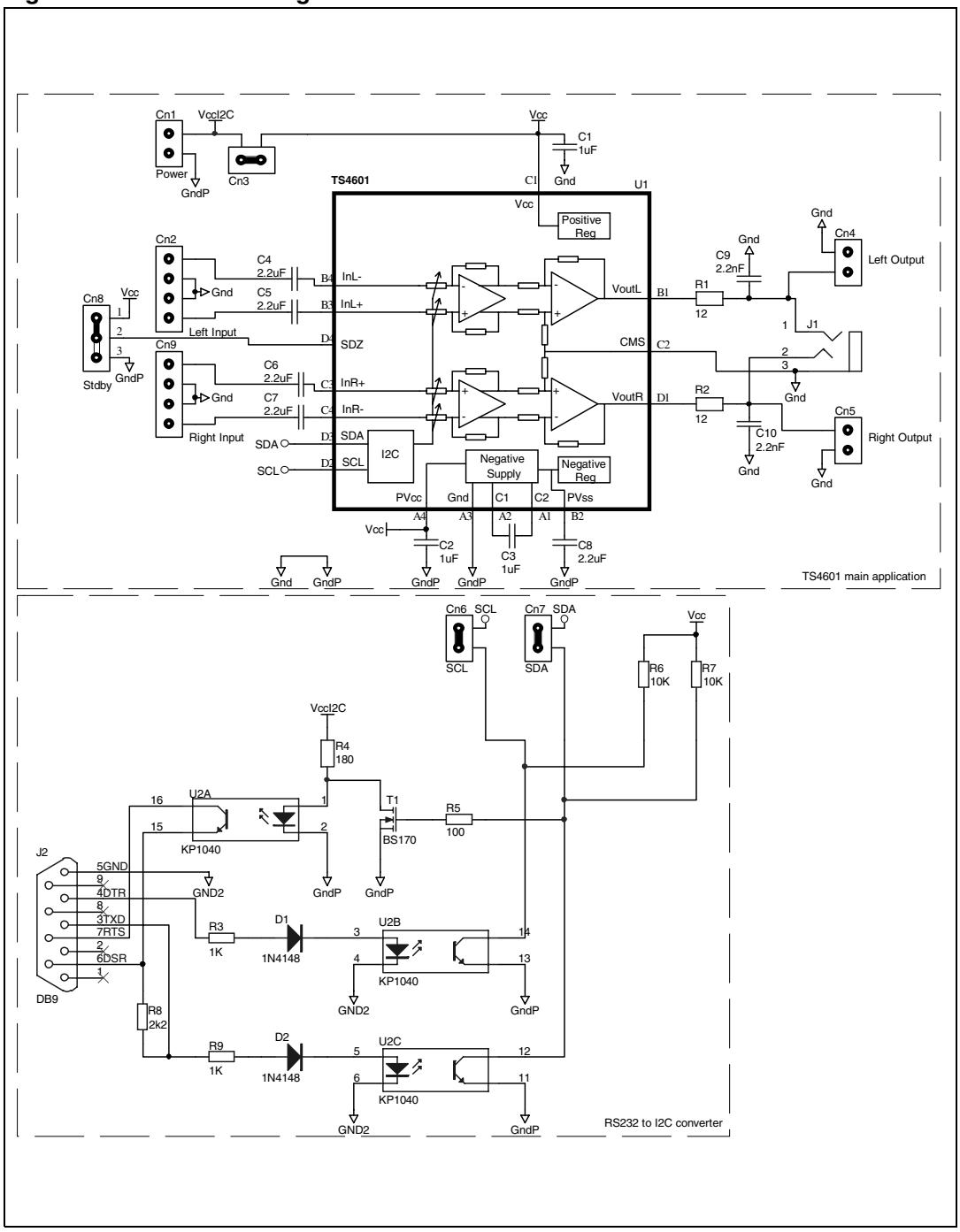


Table 2. Component list for the demonstration board

Name	Quantity	Description
C1, C2, C3	3	1 µF/10V X5R, SMD ceramic capacitors, 0603
C4, C5, C6, C7, C8	5	2.2 µF/10V X5R, SMD ceramic capacitors 0603
C9, C10	2	2.2 nF/50V X7R, SMD ceramic capacitors, 0603
Cn1, Cn3, Cn4, Cn5, Cn6, Cn7	6	2-pin header 2.54 mm pitch
Cn8	1	3-pin header 2.54 mm pitch
Cn2, Cn9	2	4-pin header 2.54 mm pitch
D1, D2	2	1N4148,
J1	1	3.5 mm stereo PCB headphone jack connector
J2	1	PCB 90° female DB9 connector
R1, R2	2	12 Ω/1% SMD resistor, 0603
R3, R9	2	1 kΩ/1% SMD resistor, 0603
R4	1	180 Ω/1% SMD resistor, 0603
R5	1	100 Ω/1% SMD resistor, 0603
R6, R7	2	10 kΩ/1% SMD resistor, 0603
R8	1	2.2 kΩ/1% SMD resistor, 0603
T1	1	BS170
U1	1	TS4601BEIJ
U2	1	KP1040, TLP521-4(GB)

2 Demonstration board layout

The following figures show the layers and the top view of the demonstration board.

Figure 3. PCB top layer **PCB mid layer 1**

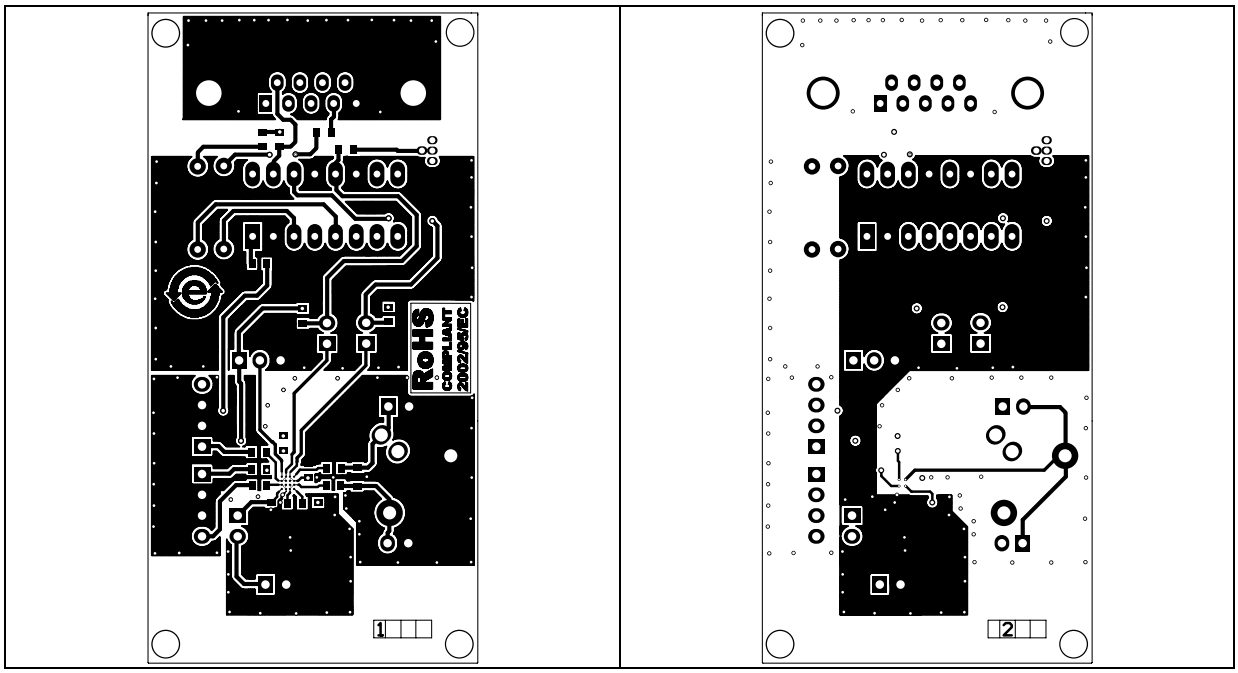


Figure 4. PCB mid layer 2 **PCB bottom layer**

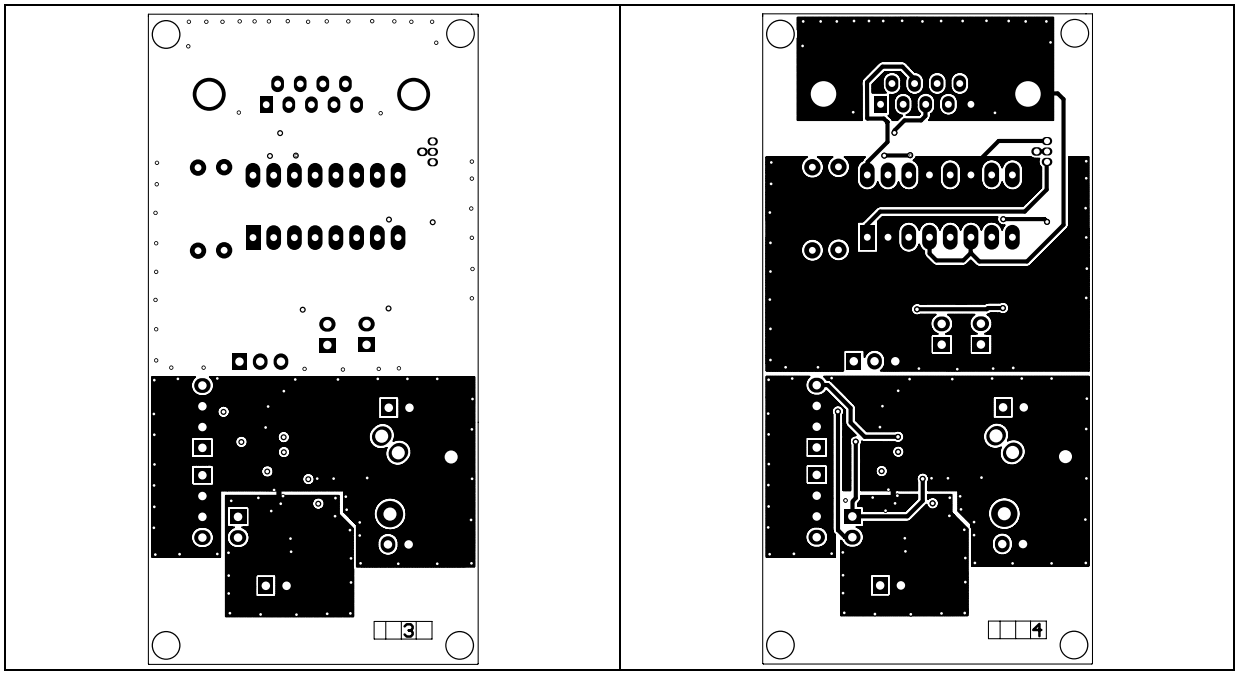
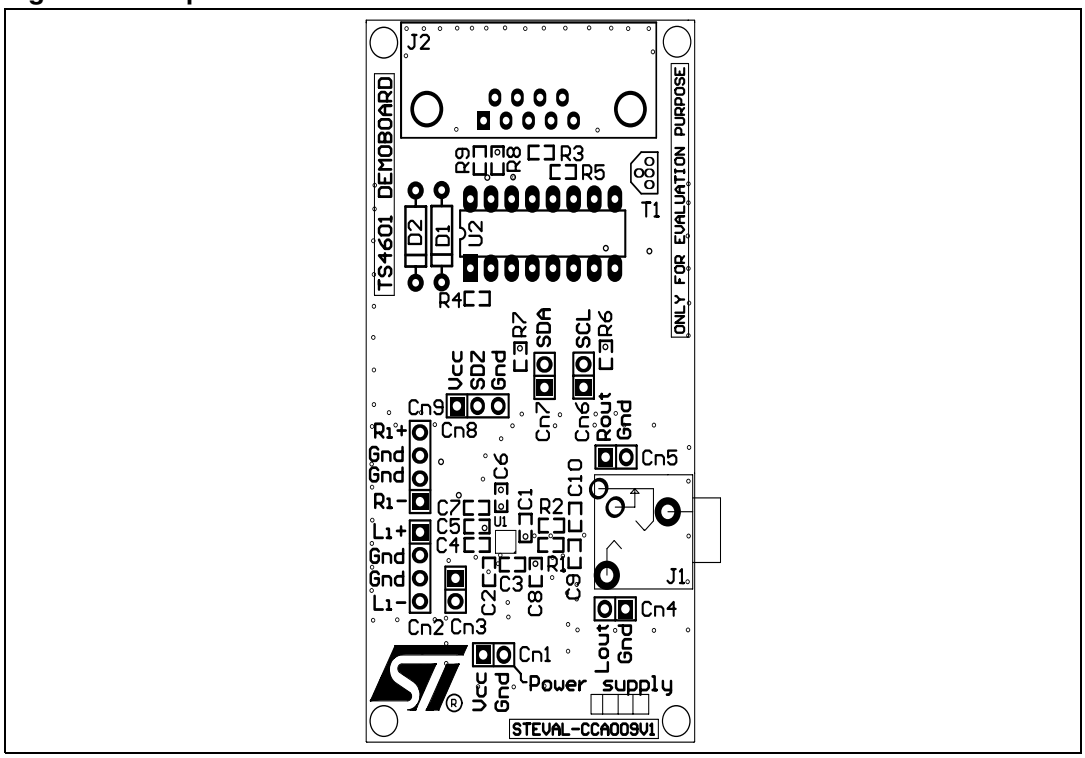


Figure 5. Top view of the demonstration board



3 TS4601B demonstration software

The TS4601B demonstration software provides a quick and easy way of driving the TS4601B audio system from a PC, and in particular, of configuring the output mode and the volume.

The software is located on the CDROM provided with the demonstration board. The latest revision of this software is available on the ST web site at *www.st.com*. It runs under MS Windows 95/98/ME/2000/XP.

The PC must have a serial port available. If not, a USB-to-serial adapter can be used but note that the compatibility with all adapters available on the market has not been tested.

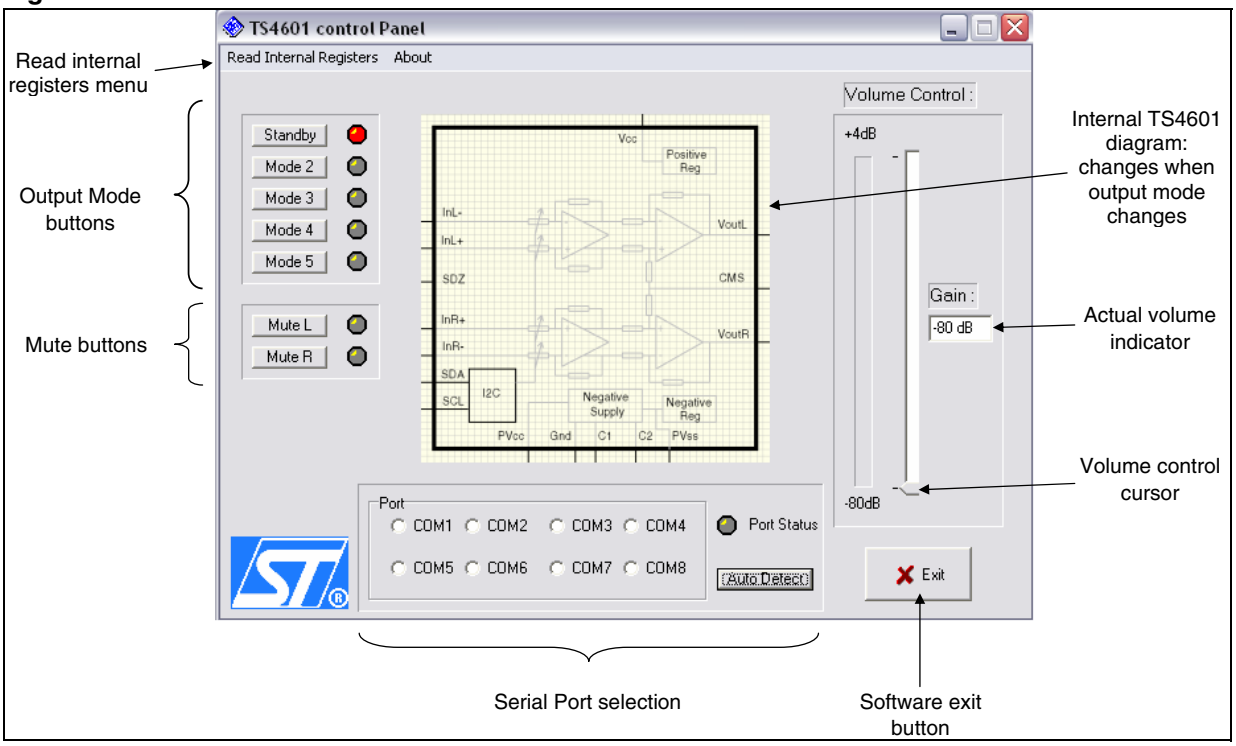
3.1 Connecting the demonstration board and starting the software

Follow these steps to drive the TS4601B from a PC.

1. Use a DB9 female to DB9 male RS-232 cable to connect the PC to the TS4601B demonstration board on J2.
2. Connect the power supply V_{CC} to Cn1, and set the jumper on Cn8 to short pin 1 and pin 2.
3. Verify that Cn3, Cn6 and Cn7 are shorted.
4. Connect the modulation source to Cn2 and Cn3, and plug a headphone into J1.
5. Copy the TS4601B demonstration board program `board.exe` provided on the CDROM onto the hard drive of your PC and launch it by double-clicking on it (no installation needed, you can just copy it).

   The software dialog box shown in *Figure 6* is displayed.

Figure 6. TS4601B demonstration software main window



6. Choose the appropriate COM port from the **Port** area or click **Auto Detect** for the program to select the COM port automatically.

   When the **Port Status** indicator turns to green, the program is ready to send commands to the TS4601B.

   In some rare cases, when auto detect is used, a COM port is chosen (**Port Status** is green) but it is not the right one. If this happens, manually force the right COM port by clicking directly into the Port box.

Note: The COM port where the device is connected must be in the range of COM1 to COM8. If this is not the case, change the COM port number in Windows by selecting ***Start>Control Panel>System>Hardware>Device Manager.***

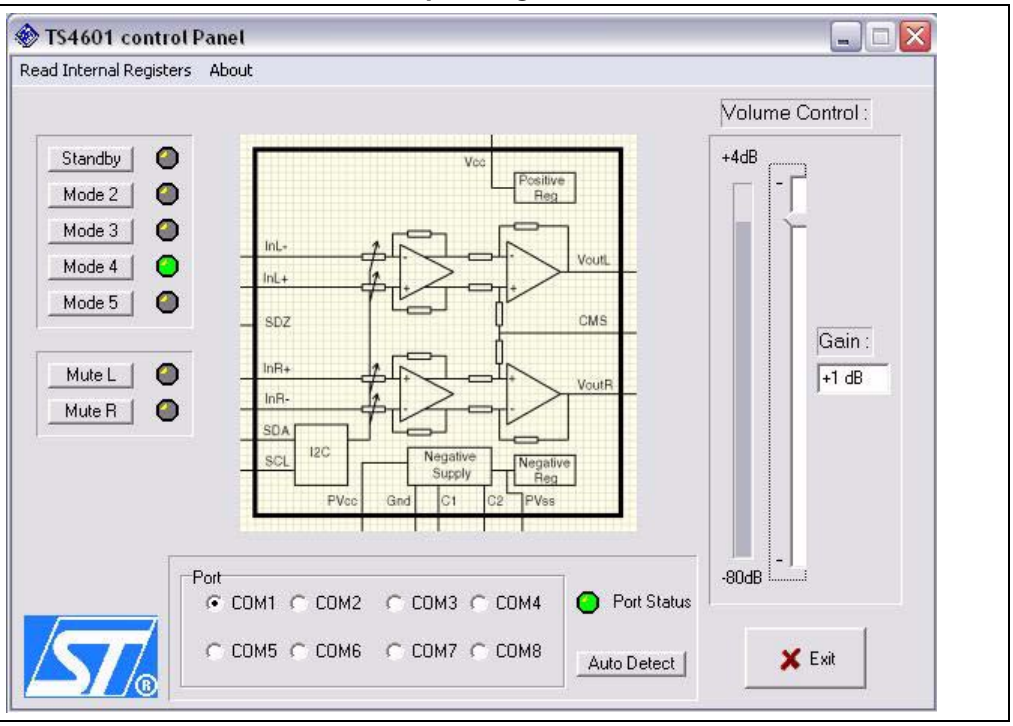
3.2 Using the TS4601B software

In the main window of the TS4601B demonstration software shown in *Figure 6*, on the left side the following features are available.

- **Mode select buttons**

  Allow you to select the TS4601B output mode. The diagram located in the middle of the window summarizes the mode currently selected and shows which inputs and outputs are active. The indicator located to the right of each output mode lights up when the mode is active. *Figure 7* shows an example of this window when the software is in operation.

Figure 7. TS4601B main window in operating mode



- **Mute buttons**

  Allow you to set the TS4601B output to mute or operating mode. When the indicator located to the right lights up in green, the channel mute is active.

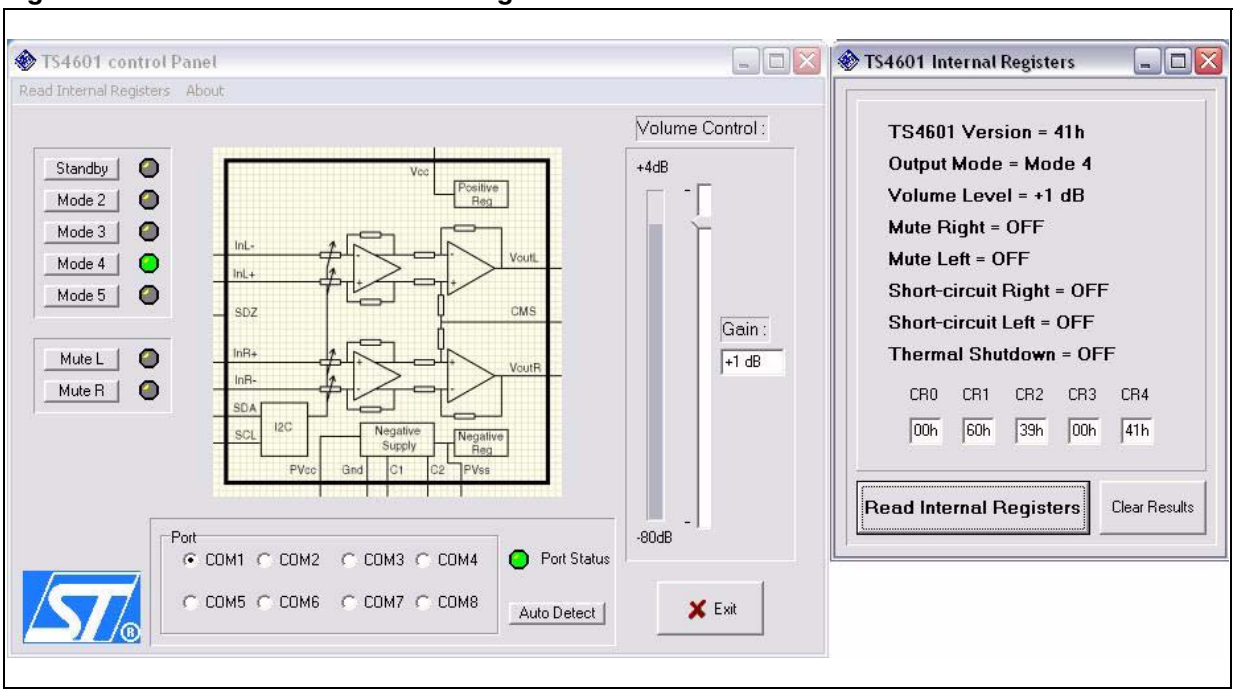
- **Read internal register menu**

  When you click on this menu, the **TS4601B Internal Registers** pop-up window is displayed (see *Figure 8*). By clicking on the ***Read Internal Registers*** button, you can display the actual state of the TS4601B. Hexadecimal values of CR0 to CR4 registers are also displayed. By pressing the ***Clear Results*** button, all results disappear and you need to press again the ***Read Internal Registers*** button for a new display.

  Note that this window remains open until you close it by clicking on the cross in the upper right corner.

  Note also that this window is not automatically refreshed. If you change the output mode or something else in the main window, you have to press again the ***Read Internal Registers*** button to display the new TS4601B settings.

Figure 8. TS4601B main window + register status window



In the main window of the TS4601B evaluation software shown in *Figure 6*, on the right side the following feature is available.

- **Volume control cursor**

  By dragging this cursor up and down, you can control the TS4601B's output volume. The actual gain set is displayed in the **Gain** box.

To exit the program, just click the **Exit** button on the bottom right or click the cross in the upper right corner of the window.

Note: Occasionally, problems may arise when trying to drive the demonstration board using certain notebook or laptop PCs and the RS-232 output.

3.3 Common error messages

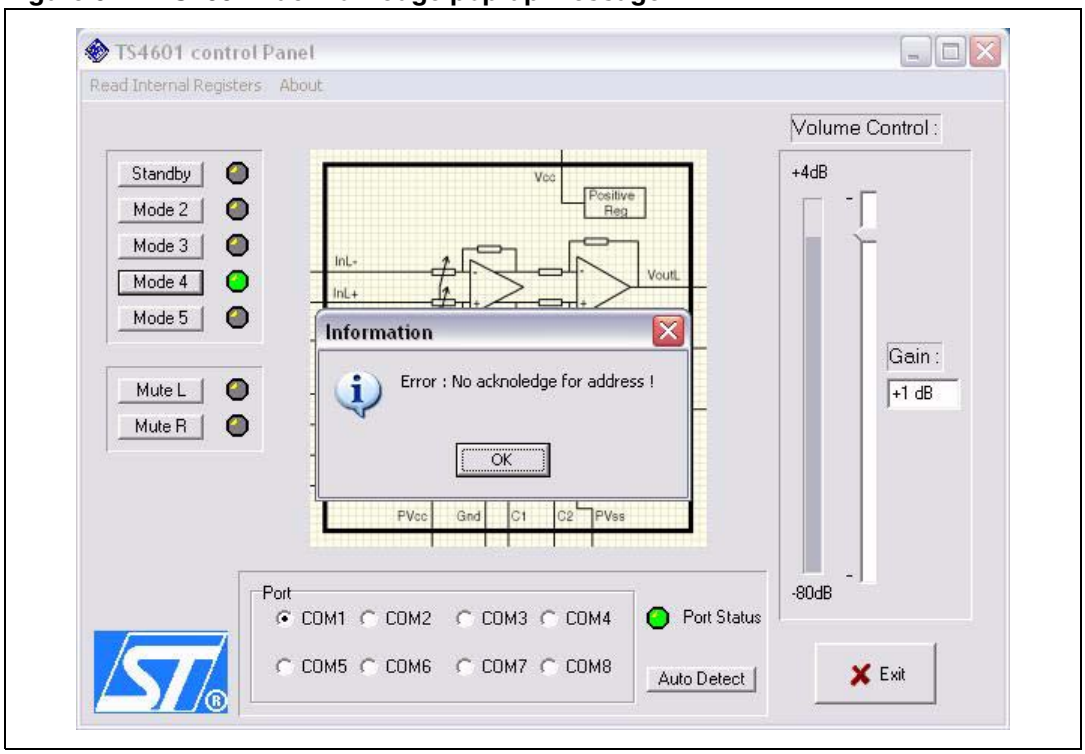
No acknowledge for address

You pressed an output mode button and the software displays an information pop-up window that indicates “Error: No acknowledge for address!” (see example in *Figure 9*).

This error message can have several causes.

- You set the device in master standby mode. Either Cn8 between 2 and 3 or the SDZ pin were left floating.
- The power supply is down or disconnected from Cn1.
- One or several jumpers are missing on Cn6 or Cn7.
- The serial cable is disconnected from J2.
- The jumper on Cn3 is missing and there is no amperemeter in series.

Figure 9. TS4601B acknowledge pop-up message



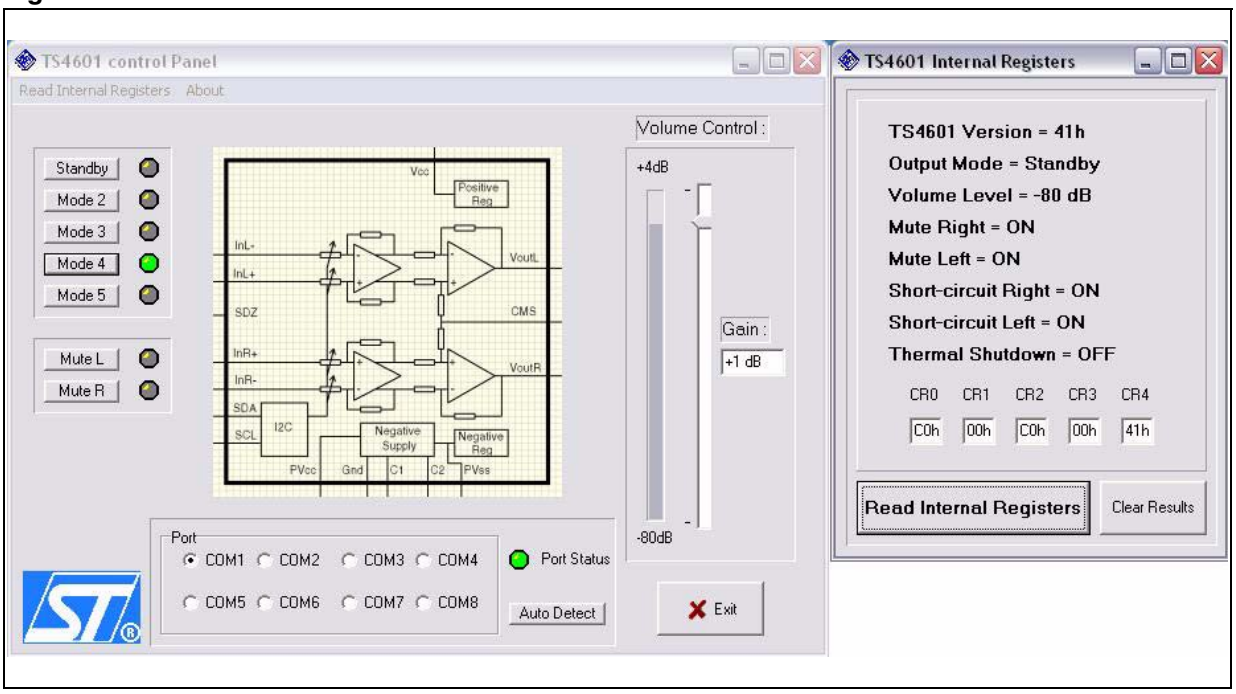
Results displayed in *Internal Registers* window are different from main window

You pressed the read internal registers button in the TS4601B internal registers window, and results displayed are different from what the main window indicates (see *Figure 10*).

The main window is not automatically refreshed, therefore, this case can appear if, while the software is running, you switch the TS4601B power supply OFF and ON or set the TS4601B to master standby (by setting the pin SDZ to "0") and set it back again to I^2C standby (SDZ to level "1"). When you do this, the TS4601B is reset and all internal registers are set to their initial value. This is why, when you press the ***Read Internal Registers*** button, the result displayed is quite different from the display in the main window.

Pressing again one of the output mode buttons or just changing the volume is enough to re-start the TS4601B without closing and re-starting the software.

Figure 10. Uncorrelated windows in TS4601B evaluation software



4 Revision history

Table 3. Document revision history

Date	Revision	Changes
17-Apr-2008	1	Initial release.
13-Mar-2009	2	Minor text changes. Changed part number from TS4601 to TS4601B.

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